



Research & Development for Off Road Fuel Cell Applications

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IdaTech's Family of Reliable Fuel Cell Solutions

Timeline

- Start date: Sept 2004
- End date: June 2010
- Percent complete: 30%

Budget

- Total project funding
 - DOE share \$1,084,488
 - Contractor share \$464,780
- Funding received in FY07
\$36,520
- Funding for FY08 \$333,793

Barriers

- Air-filtration for off-road applications
- Impact of S&V

Partners

The Toro Company

University of California – Davis

Donaldson (Previous)

Task -1 Load Study

- Toro Measured Loads

- Toro Reported Vehicle Modifications and Specifications

Task - 2 Shock & Vibration

- Reported on S&V Profiles and Lifetime – UC Davis

- Complete S&V of Fuel Cell System (FCS)

Task - 3 Contamination and Air Quality

- Donaldson Measured Contaminants and
Developed Air Filter

Task - 4 Fuel Cell System Specification Assessment (Toro completed)

Task - 5 Install PEM Liquid Fueled System in Golf Course Maintenance Vehicle

Toro Workman e2065 Maintenance Vehicle

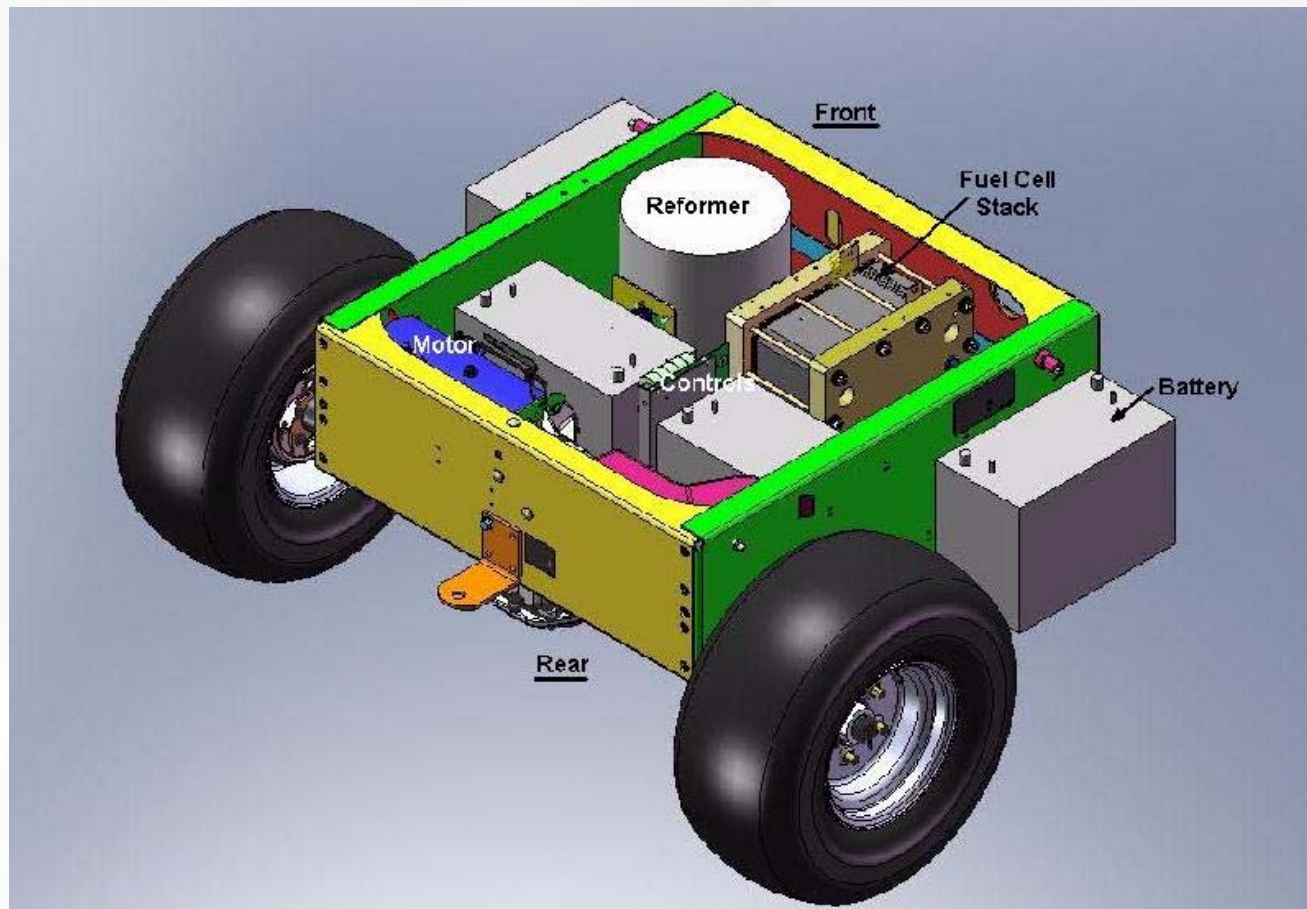


- Purchase test platform (Workman e2065 vehicle)
- Modified three 1 kW Fuel Cell Systems (FCS) to produce 2.5 to 3.5 kW each
- Deliver FCS to UC Davis for shock & vibration testing
- Install FCS in test platform
- Dynamometer testing of test platform
- Start field trials of test platform
- Complete shock and vibration initial testing

FY 09 Milestone Plan

- Second prototype upgraded design
- Demonstrate vehicle at selected venues

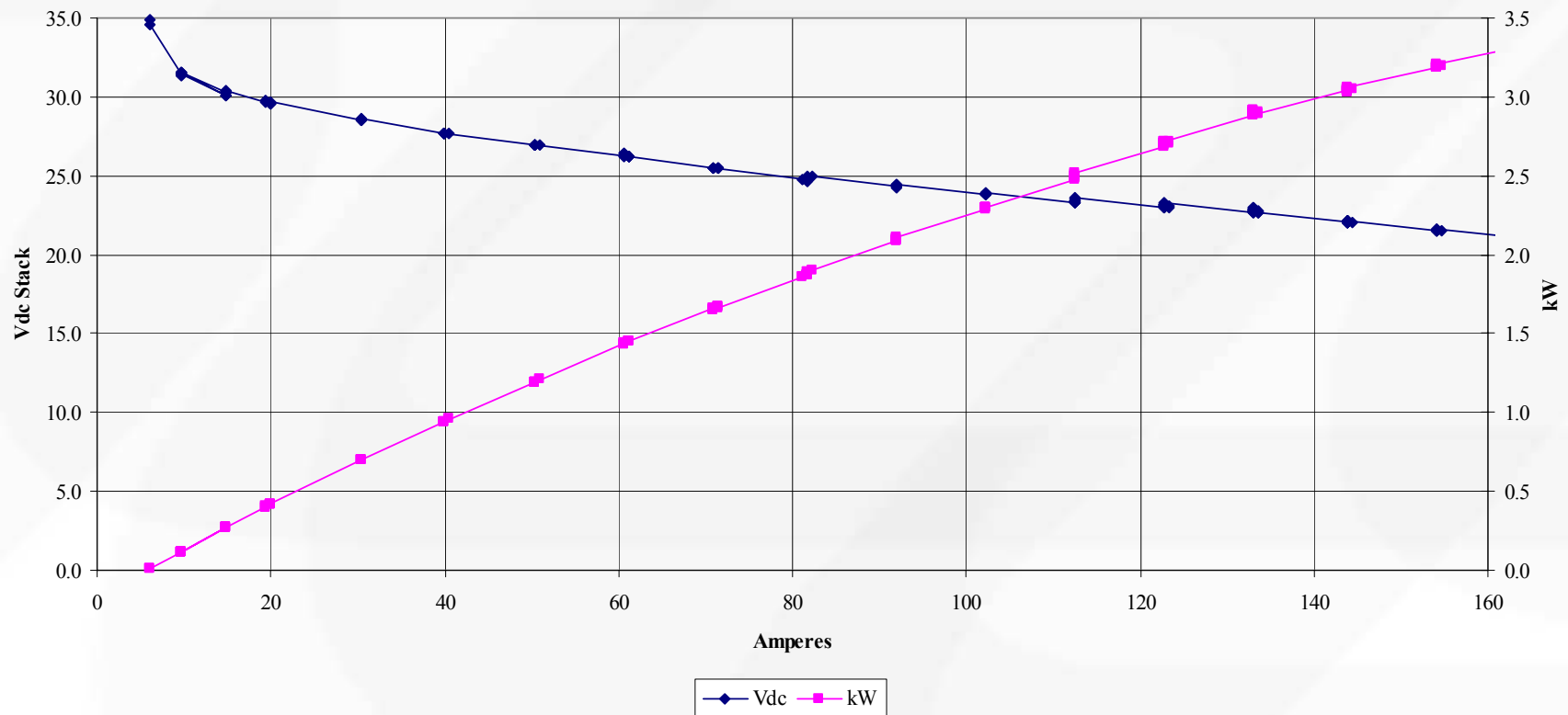
Computer Model IdaTech Fuel Cell System in Vehicle



- Purchase Workman e2065 battery powered golf course maintenance vehicle, install upgraded batteries in vehicle, and install fuel tank.
- Modified three 1 kW Fuel Cell Systems (FCS) to produce 2.5 to 3.5 kW and redesign/repackage for installation in vehicle.
- Perform S&V testing of FCS.
- Performance test vehicle on dynamometer, on golf course, and with course maintenance personnel.
- Design second prototype updated with S&V, field trials results, and design for manufacturing.
- Demonstrate vehicle at selected venues.

Power Curve

IdaTech - Off Road Stack Power



FCS Charging Batteries on Vehicle



FY 08

- Perform S&V testing of FCS.
- Install FCS in vehicle.
- Performance test vehicle on dynamometer, on golf course, and with course maintenance personnel.

FY 09

- Design second prototype updated with S&V, field trials results, and design for manufacturing.
- Demonstrate vehicle(s) at selected venues.

- This project was started 9/04 and suspended 12/05.
- The project was restarted 8/07. During the suspension the following were completed by the partners:
 - Toro – Measured shock & vibration and power loads on two golf courses
 - Donaldson – Measured air quality on two golf courses
 - Toro - PEM fuel cell system specification for grounds maintenance vehicles and developed ECM and motor
 - Toro – determined that compressed hydrogen is unacceptable for maintenance vehicles, developed requirement for on-board liquid fueling
 - Donaldson - developed air filter
 - IdaTech developed a 3.5 kW liquid fueled FCS

Critical assumptions for FCS:

- It will physical fit into vehicle.
- It can provide required energy during field testing
- It can function under applications' shock and vibration loads

Potential Solutions:

- Modify vehicle
- Improved controls and response
- Incorporate shock and vibration test results